colleagues[7] and modified by Grillo.[8] In this technique the stenosis is transected at its midpoint. The 2 ends are spatulated by a longitudinal slit on the anterior surface of one end and the posterior surface of the other end. The spatulated ends are then advanced over one another and sutured together in an extended end-to-end fashion. This technique has proved to shorten intubation times because patients are typically extubated in the operating room. Subsequently, this also shortened hospital stays. Another advantage of slide tracheoplasty is the avoidance of graft material, the low rate of granulation tissue formation, and therefore the less frequent requirements for postoperative bronchoscopy. Tracheal reconstruction has been plagued by the frequent development of granulation tissue formation and postoperative tracheal stenosis. Although we have adopted the technique of avoiding the tracheal mucosa in the suture line, 10 (38%) of 26 of the patients had some evidence of granulation tissue at postoperative bronchoscopic surveillance. Although this is more of a nuisance, 2 patients did require tracheostomy. One underwent tracheostomy 5 months postoperatively because of exuberant granulation tissue in addition to tracheal scarring below the level of the patch. The second patient underwent tracheostomy related to distal tracheal stenosis. The remaining 8 patients were treated with a single procedure and did not exhibit any future evidence of airway obstruction or granulation tissue.

Repair with tracheal autograft has emerged as a new technique to treat long-segment congenital tracheal stenosis. This technique, however, does not always solely address the length of the stenosis. In a series of 9 patients who underwent repair by means of tracheal autograft, 5 of these patients required augmentation with a pericardial patch. Furthermore, 1 case was complicated by autograft dehiscence, a problem not seen in our series with the pericardial patch.[9-11]

In contrast to techniques that involve reconstruction of the native trachea, neither the length nor the location of the stenosis is a technical limitation to anterior pericardial tracheoplasty. The pericardial patch has been used to treat stenoses that extend to the mainstem bronchi; reconstruction of the native airway can become complicated when the bronchus is involved.

The mortality rate of pericardial patch tracheoplasty is comparable with that of other techniques. This is reflective of the finding that tracheal stenosis is commonly associated with other severe defects and their attendant morbidities. In this series, of the 5 patients who died, 4 also had other complex intracardiac abnormalities, and 1 patient had severe bronchopulmonary dysplasia. The highest mortality rate observed after surgical repair of congenital tracheal stenosis is observed in patients younger than 1 month and those with intracardiac anomalies.[12]

Limitations to this study include the small number of patients. Congenital tracheal stenosis is notably a rare disease. The few studies that do address this problem are limited by the number of patients. In addition, this study is limited as a retrospective chart review. Therefore objective data, such as postoperative tracheal diameter, and data from functional studies, such as spirometry, were not obtained routinely. Also, a few patients were lost to follow-up.

In summary, anterior pericardial tracheoplasty is an attractive therapeutic option for small infants and children with long-segment tracheal stenosis. Major advantages to this technique include (1) no restrictions for a patient's age and size, (2) no technical limitations based on the length and location of the stenosis, and (3) the possibility of concomitant repair of cardiac lesions. The majority of survivors in this series remain asymptomatic and enjoy a good quality of life.

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Discussion

Dr Gordon Cohen *(Seattle, Wash)*. I want to thank the association for the opportunity to discuss this important article by Dr Fanous. The article is another example of excellent work done by Dr John Brown and his group at Indiana University.

This article reports the long-term follow-up of their experience treating congenital tracheal stenosis with anterior pericardial tracheoplasty over a 22-year period. Congenital tracheal stenosis is a very complex problem, and the surgical approach to this entity varies from center to center. Although numerous surgical procedures have been described, there is no clear consensus on the best surgical treatment for this condition. The reason for the lack

of unity is likely the rare nature of the condition itself and the absence of any long-term follow-up for any given technique. The article presented today by Dr Fanous provides us with some insight into the long-term outcomes of one of the more widely used techniques: anterior pericardial tracheoplasty.

Dr Fanous, I have a few questions for you today, and I will give you the opportunity to answer each one as I go so you do not have to remember all this.

One of the common problems associated with anterior pericardial tracheoplasty is the formation of granulation tissue within the tracheal lumen. The granulations themselves can be extremely problematic. The incidence of this problem is quite high; in fact, you reported it to be as high as 38% in your series. Given the high incidence and the potential of severity of these granulations, do you have a surveillance protocol to look for granulation tissue, and if so, what does that protocol involve, and how do handle the granulations when you find them?

Dr Fanous. Thank you very much. Our patients are usually intubated from 1 week to 14 days postoperatively. Before extubation, they undergo bronchoscoipc evaluation, and at that time, if the patient's airway is otherwise intact without granulation tissue, then we proceed down the extubation pathway. Bronchoscopy is not done routinely after extubation unless there are other respiratory or airway symptoms. Of the 10 patients who did have granulation tissue in our series, 1 had exuberant granulation tissue combined with stenosis and did go on to require tracheostomy. The other 9 patients were all dealt with through bronchoscopic removal of the granulation tissue. Therefore we saw that more as a nuisance rather than a devastating complication.

Dr Cohen. And long-term, did you see any granulations and have any need for ….

Dr Fanous. There is 1 patient. One of our patients who still has a tracheostomy to this day and has granulation tissue that still requires removal periodically.

Dr Cohen. Some centers use slide tracheoplasty as their preferred surgical approach for the treatment of congenital tracheal stenosis. The benefit to slide tracheoplasty is that you reduce the formation of granulations, and you have early extubation. Does your center have any experience with alternate techniques, such as slide tracheoplasty, and if so, what would have been your results with that procedure? In addition, if you have these multiple techniques, what has been your algorithm for deciding which surgical approach to take?

Dr Fanous. We do, in fact, most commonly use the anterior pericardial tracheoplasty for these patients. There have been a handful of patients who have undergone slide tracheoplasty, and we find that when the stenoses are of very long segments—and 1 patient had up to 22 rings—it is technically easier to use the pericardial patch. Although we do acknowledge that the granulation tissue is limited with the use of slide tracheoplasty and the patients are extubated earlier, sometimes in the operating room postoperatively we do not use it because our experience has been mostly with pericardial tracheoplasty.

Dr Cohen. In those patients in whom you decided to do a slide tracheoplasty, is there a cutoff for a certain number of complete tracheal rings that you would use to make that decision?

Dr Fanous. For a long segment, greater than 5 or 6 rings, we go to a pericardial tracheoplasty.

Dr Cohen. As a follow-up to that question, in your hands anterior pericardial tracheoplasty seems to have a relatively low operative mortality. However, in the meta-analysis that you showed, tracheal resection, which is not always possible, followed by slide tracheoplasty had a much lower operative mortality than pericardial tracheoplasty. Again, given the lower incidence of complications and the lower mortality, should we as a field not adopt slide tracheoplasty as a preferred treatment method when it is technically possible? Do you have an opinion on that?

Dr Fanous. If slide tracheoplasty has good outcome in the surgeon's hands and the surgeon is confident in performing that technique and there is not a long length of stenosis, I think that is very acceptable.

Dr Cohen. Finally, I have a technical question. In your article you describe harvesting fresh pericardium. Do you use the pericardium in the untreated state, or do you treat it with glutaraldehyde? If you use it fresh, have you had any problems with early shrinkage of the patch requiring reintervention?

Dr Fanous. The patch is used as a fresh patch. Our thought behind that is that we prefer to put in living tissue as a bed for future growth and future vascularization. We do believe that there is some shrinkage of the patch, and that is the reason why we enlarge the proposed diameter to greater than 1½ times normal as adjusted for age and size.

Dr Cohen. Drs Fanous and Brown, congratulations on your excellent success with this complex group of patients. Your report of long-term outcomes is an important addition to our body of knowledge.

Thanks again to the association for the opportunity to discuss this article.

Dr Douglas Wood *(Seattle, Wash)*. I congratulate you on your outcomes, but I am going to push a little farther with Dr Cohen's questions and criticisms. I think that in the ear, nose, and throat literature and in the thoracic surgery literature in general, tracheoplasty procedures have not been shown to have as durable a result as tracheal resection and use of the native trachea in reconstruction. It is easy to understand why. One is taking a dead piece of tissue and putting it in part of the trachea to augment the trachea in an environment that is chronically contaminated; it is no wonder that there will be chronic granulation tissue and that healing can only occur really by means of contracture and fibrosis. It is actually encouraging that in spite of this, a number of patients can end up having good outcomes. Yet there is now a better technique, a technique of slide tracheoplasty that does suffice for a full segment of tracheal stenosis and allows the use of the native trachea to augment the trachea with better outcomes, as shown by Dr Backer and his colleagues in Chicago. I think that your results are very good, but I guess I would allege that when one looks at the results in airway surgery, there would still be a pressure to move forward to evolving to slide tracheoplasty for the vast majority of patients rather than augmentation tracheoplasty.

Dr Fanous. Thank you. Although we do acknowledge that use of the native trachea for a tracheal reconstruction is ideal, in many situations it is not possible because of long length, and sometimes the tracheal stenosis involves one of the mainstem bronchi or even a trifurcation of the trachea. In those cases reconstruction through the slide tracheoplasty technique can be very difficult. In addition, many of these patients have congenital cardiac malformations that require repair at the time of the tracheoplasty. In this situation the

patients are already undergoing cardiopulmonary bypass, which might not be necessary for slide tracheoplasty, and therefore in essence it can kill 2 birds with 1 stone.

Dr Wood. I respectfully disagree. I think slide tracheoplasty is effective for even long-segment tracheal stenosis. Its very design is to be able to accomplish that. At least in the pediatric population, my understanding is that almost all of these are done during cardiopulmonary bypass through the same anterior approach and with the same ability to correct congenital cardiac defects at the same time.

Dr Fanous. My understanding is that there are some groups that perform slide tracheoplasty without the use of cardiopulmonary bypass. We are not saying that pericardial tracheoplasty is a better option, but we are saying that it is safe and is a durable option with good long-term outcomes. Slide tracheoplasty and tracheal autograft are also good techniques.